AMIOTIC PARTHENOGENESIS IN TARAXACUM VULGARE (LAM.) SCHRK. AND TARAXACUM LAEVIGATUM (WILLD.) DC.

A Preliminary Peport.*

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The work of which the results are here offered, awaiting detailed presentation in a paper to follow, was begun at the University of Nebraska in 1914, under the direction of the late Dr. Charles E. Bessey. The two species of dandelion which have been studied are respectively the *Leontodon taraxacum* and the *L. erythrospermum* of the Second Edition of Britton and Brown's Illustrated Flora: the nomenclature used in the title of this paper has been adopted on the basis of evidence presented in the monograph of the genus *Taraxacum* by Handel-Mazetti.[1]

Both of these species were among the number found by Raunkiaer[2] to be "parthenogenetic" when he performed his classic castration experiments in 1903. His operation, which consists of removing anthers and stigmas before anthesis, and subsequent protection from pollination, has been frequently and successfully repeated in the case of both species, without affecting the viability of the seeds produced.

Moreover, the observations of various authors, notably Raunkiaer[2] and Kirschner[3], to the effect that its own pollen is not to be found germinating on the stigmas of *T. vulgare*, are true for both species investigated, so far as known. Whether or not the pollen of sexual species of dandelion would germinate on the stigmas of either of these forms is not to be ascertained by work here, for such sexual species are unknown in the mid-western United States.

In both species, to-wit, the grey-fruited and red-fruited dandelions, the development of the embryo-sac has been carefully studied. The embryo-sac-mother-cell, or megasporocyte, only divides once, forming two daughter cells with the somatic or 2x chromosome content. Juel,[4] of course, in 1904, found this to be true of *T. vulgare*, but I am aware of no similar investigation in the case of *T. lævigatum*. In both species one of the daughter cells degenerates, while the remaining one gives rise to an embryo sac of normal eight-nucleate type, but with

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unreduced chromosome content. In *T. vulgare* the chalazal daughter cell gives rise to the embryo sac, while in certain cases at least, it is the micropylar daughter cell which seems to function in *T. lævigatum*. That this distinction is constant is scarcely to be expected.

There is, however, an equally interesting, and apparently constant difference in the form of the embryo-sac of the two species, the embryo-sac of *T. vulgare* being fully one-half as wide as long at maturity, while that of *T. lævigatum* is scarcely one-fourth to one-third as wide as long at the corresponding stage. This difference is reflected to some extent in the form of the ripened achenes.

In both forms the egg-cell gives rise to the embryo sporophyte without apparent external stimulus or sexual fusion. Division of the egg cell very frequently begins a considerable time before the opening of the flower and is accompanied by rapid (often amitotic, according to Schorbatow[5]) division of the endosperm nuclei. The fact that the embryo arises from an unfertilized egg-cell of unreduced chromosome count makes it seem advisable to employ the expression "amiotic parthenogenesis"—to describe the phenomenon, rather than the term "apogamy." This expression "amiotic parthenogenesis" is of course the equivalent of Winkler's[6] ambiguous "somatic parthenogenesis." The word "apogamy," for the sake of clearness—not the least object to be sought—should be restricted, it would seem, to cases of embryo-origin from purely vegetative tissue; just as the expression "true parthenogenesis" must be limited to embryo-origin from an unfertilized egg of haploid chromosome number.

The heads of *T. lævigatum*, the red-fruited species, contain a high percentage—often between 15% and 20%—of empty or sterile achenes, to be explained in some cases by an early breaking down of archesporial and nucellar tissue, in other cases by a failure of the ovulary to develop anything but purely vegetative tissue. Empty or sterile fruits are of rarer occurrence, so far as noted, in *T. vulgare*.

Both forms, in all cases examined both in Nebraska and Ohio, produce pollen in abundance, but even cursory inspection shows the grains to vary extremely in size. Cytological studies of both species reveal varying degrees of pollen degeneration.

Many anthers, particularly in the case of *T. vulgare*, contain in whole or in part pollen grains of normal appearance and even

size, formed in tetrads, as by means of ordinary reduction division. In other cases tetrads are found consisting of two large and two small cells. Again, in both species but particularly in the examples of *T. lævigatum* which were studied, the pollen grains are formed in groups of irregular numbers, at times as many as six or seven being found in a cluster. In such cases, wide disparity of size is the rule, the larger grains frequently being devoid of stainable nuclear material.

Finally, in the red-fruited species, *T. lævigatum*, bodies exactly like mature pollen grains in outward form are found in pairs. This type of pollen development corresponds exactly to the diads found by Osawa[7] to be so frequent in the amiotically parthenogenetic Japanese species, *T. albidum* (?). The presence of such diads would superficially suggest the complete loss of reduction division, already true of the embryo-sac-mother-cell.

Detailed studies of pollen genesis indicate that, as a matter of fact, the tetrads of normal appearance are formed by ordinary reduction division, just as they are in the sexual species of dandelion that have been investigated. In many cases observed, however, the divisions were seen to be quite irregular, in that the spindle mechanism was unable to effect a simultaneous transfer of all the chromosomes entering into the first division. This means that a varying number of chromosomes lag behind and are either (a) included in one of the two daughter nucleii, augmenting its size at the expense of the other, or (b) formed into separate supernumerary nucleii. In the former case of course a second division would result in the formation of two cells of large size, and two of reduced size, a situation which, as indicated above, is often found. In the latter of the two cases mentioned subsequent divisions might or might not occur, in either case giving rise to an irregular number of pollen grains of widely varying size and nuclear content.

Again, a number of clearly defined cases were observed in which nucleii were dividing amitotically, as indicated by dumb-bell forms and other criteria laid down by careful workers in the past. These amitotic divisions were found at times to replace the first division of the mother cell, as well as subsequent divisions. This finding also coincides with the condition obtaining in *T. albidum*, as worked out by Osawa.[7]

Finally, clear explanation of the large number of anucleate pollen grains, generally found in association with smaller grains, was found in the frequent occurrence of well-defined nuclear

extrusion; this phenomenon occurs extensively in *T. lævigatum*, and has been found in material so carefully prepared and in such well-defined stages that its genuineness cannot be brought into question. This phenomenon apparently was not observed by Osawa[7] as contributing to the pollen abnormalities of *T. albidum*. As found in *T. lævigatum*, this extrusion takes the form of a centrifugal wandering of granules of stainable material and their speedy organization into accessory nucleii so soon as they pass through the parental nuclear membrane.

Finally, the occurrence of diads, as before mentioned, is due to entire loss of the reduction division—the mother cell dividing once and both daughters forming into "pollen-grains."

In neither of the species studied is the chromosome count any lower than in any sexual species for which it has been taken, as is generally true for the amiotically parthenogenetic species of *Taraxacum* that have been investigated. Moreover, both species possess such a wide range of forms that the only safe criterion for separating them seems to be achene color and form. While this polymorphy may be correlated with what seems to be an unwieldy chromatin content—so far as the reproductive cells are concerned—nevertheless, when taken in conjunction with the observed pollen abnormalities and the chromosome count it points strongly toward hybridism, possibly quite complex hybridism, as an explanation. That this idea has the specific sanction of Blaringhem[8] and others is well known. However, I do not wish to be understood as asserting that such evidence can ever *prove* the existence of complex, or even simple, hybridism, as some workers undoubtedly believe.

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